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A COMPARISON OF RAF AND ITALIAN AIRCREW ANTHROPOMETRIC DATA.(U)

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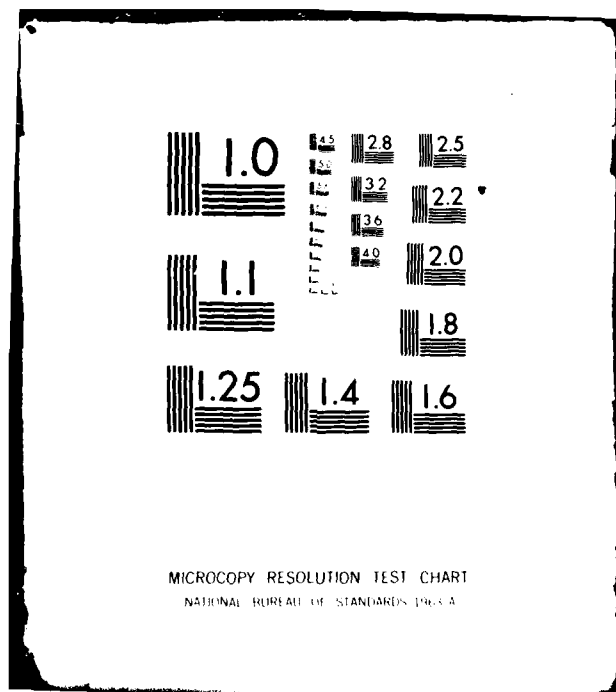
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⑥ A COMPARISON OF HAV AND ITALIAN AIRCRAFT  
ANTHROPOMETRIC DATA

by  
⑩ E. J. Harvey

⑪ November 1944

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⑨ Technical memo

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A COMPARISON OF RAF AND ITALIAN AIRCREW  
ANTHROPOMETRIC DATA

by

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SUMMARY

In view of proposed Anglo-Italian aircraft projects such as WG 34, 47 anthropometric measurements common to two population surveys have been compared. Means and standard deviations have been taken from Hertzberg's anthropometric survey of Italian pilots and from the survey of 2000 RAF aircrew.

The figures generally show that the Italian pilots have similar body and limb circumferences as the RAF aircrew. The Italian linear dimensions are, however, considerably less than those of the RAF aircrew. These differences need to be taken into account when designing cockpit and rear cabin workstations.

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## 1 INTRODUCTION

An increasing number of aircraft projects are now of a dual or multi-national nature. This has direct ergonomic implications for the work station layout of the aircraft. For example, joint Anglo-Italian aircraft projects, such as WG 34 (EH101) will need to take account of anthropometric data from the user populations of both countries. Cabins and cockpits should be designed to accommodate a range from 3rd to 99th percentile operators from both populations.

This Memorandum compares 47 anthropometric measurements which are common to two population surveys of Italian pilots and RAF aircrew. These measurements are shown in Figs 1 to 3, with corresponding data given in Table 1.

## 2 DATA SOURCES

Italian pilot anthropometric measurement data has been extracted from "Anthropometric survey of Turkey, Greece and Italy" by H.T.E. Hertzberg et al<sup>1</sup>. This survey lists data from 150 anthropometric measurements taken in the early 1960s. The Italian data can be separated into that from 246 pilots, 73 flying cadets and a 'total' of 1358 military personnel. The 'total' military measurements include data from the pilots, flying cadets and ground personnel from the three Services. There are some differences between the three sets of data and this will be discussed later in section 3.1.

The British data is from "An Anthropometric survey of 2000 Royal Air Force Aircrew 1970/1971" by G.B. Bolton et al<sup>2</sup>. In this survey, 87 measurements were taken on 2000 aircrew subjects.

Because of the different measurements taken and the different measuring techniques chosen for each survey, it has been possible to compare only 47 of the measurements which are common to both surveys. However, critical measures such as sitting height, functional reach, buttock-knee length etc are included in these common data and useful comparisons of the two aircrew populations can be made.

## 3 RAF, ITALIAN PILOTS, CADETS AND TOTAL ITALIAN MILITARY POPULATION COMPARISONS

### 3.1 Population distributions

The Italian anthropometric data given in Ref 1 is most detailed for the total military population. This data, which assumes a normal distribution, is in the form of percentile tables at 5% intervals. In addition data is given for 1, 2, 3, 97, 98 and 99 percentiles. The data has been calculated from the sample of 1358 subjects. This information has been plotted (as solid lines in Figs 4 to 9) for the measures of stature, sitting height, functional reach, knee height, buttock-knee length and neck circumference. The means of these measures are shown as crosses for the 246 Italian pilots and the 73 flying cadets in Figs 4 to 9. It has been assumed that the shape of the distributions of pilot and cadet will be similar to that of the total population, of which they both form a part. Thus pilot and flying cadet distributions are shown as dotted lines in Figs 4 to 9. Also shown in Figs 4 to 9, as solid lines, are the distributions for the 2000 RAF aircrew.

In the case of linear measurements, it can be seen that the Italian Military (total) population is smaller than the RAF flying population. Generally, the Italian pilot and flying cadet populations occupy positions between the other two populations. Functional reach (see Fig 6) is an exception to this, since Italian pilots' mean reach is less than that of the total Italian military population.

With circumferences, the Italian military population are still smaller than the RAF aircrew, but the Italian pilots have similar, or even larger measurements than the RAF. (See Fig 9.) The Italian cadet mean circumferential values tend to be less than even the Italian military populations.

It should be noted that despite these trends, the range of RAF measurements that were recorded in the 2000 survey produced extremes which sometimes exceeded the range of the 1st percentile Italian to the 99th percentile RAF population. These extreme RAF individual measures are shown as circled crosses in Figs 4 to 9.

### 3.2 Age and time effects

One of the reasons for the anthropometric differences between the mean measures for Italian pilots and flying cadets may be age. The mean age of the Italian pilots at the time of the survey was 30.8 years, whereas the flying cadet mean age was 21.1 years.

It is generally accepted<sup>3</sup> that in recent times there has been a worldwide trend towards increased height and other measurements. Comparisons<sup>3</sup> of weight, stature and sitting height of USAF flying personnel measured in 1950 and 1967 show that the means have increased by 4.51 kg, 18 mm and 19 mm respectively - approximately a  $\frac{1}{4}$  kg and 1 mm/year, respectively. These increases have been explained by improved nutrition and factors such as heterosis - the increase in size that results from interbreeding between different populations. Thus some of the differences between Italian pilots, flying cadets and the total military populations may be due simply to time effects. Similarly, some of the differences between Italian pilots and RAF aircrew anthropometry may again be due to time effects, since although the population age means are identical (30.8 years), the surveys were separated by about 10 years in time. Thus the effect of increasing size with time might reduce some of the size differences between the two surveys. However, it is likely that these effects of increasing size with time are still continuing and although Figs 4 to 9 may slightly overestimate the differences between populations, there still will be significant differences between the Italian and RAF aircrew populations.

### 3.3 Means and standard deviations

Table 1 compares 48 means and standard deviations (sd) of Italian pilots with similar data for RAF aircrew and Italian flying cadets. Also shown are the equivalent RAF percentiles for the Italian pilot means, eg measurement 1 (neck circumference) shows that the Italian mean value is equivalent to 57th percentile RAF aircrew.

Despite differences between means, the sds for the Italian pilot and RAF aircrew populations generally are within 10% of each other. This tends to confirm that population distributions are of similar shape.

There are, however, some inconsistencies in the data. For example, the mean Italian pilot thigh circumference is equivalent to 31st percentile RAF aircrew, yet Italian pilot thigh clearance (which is a related measurement) is equivalent to 72nd percentile RAF aircrew. One can only conclude that these measurements were taken by different methods in each survey.

Similarly, Measurements 46, mean Bitragion Diameter and Bitragion-Coronal Arc (37) for Italian pilots are equivalent to 92nd and 60th percentile RAF aircrew. These are against the trend of other Italian pilot head measurements which are generally much smaller than the RAF measurements. Again, these are likely to be due to different measurement techniques used in the two surveys and to difficulty in defining precise anatomical measuring points, rather than to real differences between the two populations.

Measurement 19, foot breadth shows that the Italian pilot mean appears to be equivalent to 93rd percentile RAF aircrew, yet foot lengths and foot circumferences of each population are similar (eg 52nd and 55th percentile equivalents respectively). On examination, it appears that the foot breadths were measured by different methods and thus it is invalid to compare the figures given here for foot breadth. Differences in Measurements 11, 15 and 33 of crotch length and shoulder heights also would appear to be due to variations in measurement techniques, rather than to real population differences.

As far as can be ascertained from the measurement technique descriptions given in Refs 1 and 2, the remaining measurements have been taken using similar methods in both surveys. Direct comparisons of the means of these measurements should therefore be valid. Thus, apart from the 7 measurements discussed above, the means listed in Table 1 show two trends.

Firstly, circumferential measurements show that the population means are similar for both populations. The RAF equivalent percentiles of the Italian pilot means are 57, 50, 55, 50, 31, 50, 31, 54, 52, 55 and 27 for the 11 circumferential measurements.

Secondly, the means of the linear measurements for body, limbs and head for the Italian pilots are much smaller than the RAF aircrew means. Typically, the Italian pilot mean is equivalent to the 27th percentile RAF aircrew.

#### 3.4 Implications of differences between the two populations

Although the differences between the Italian pilot and RAF aircrew populations are not particularly large, they are sufficiently great to increase the difficulty in accommodating 3rd to 99th percentile ranges of both populations.

Of the most critical dimensions of sitting height (35), buttock-knee length (27), knee height (24) and functional reach (25), the last is particularly important. It is, unfortunately, the one Italian pilot dimension that is considerably less than that of the RAF population, the mean value being equivalent to only 5th percentile RAF aircrew. It is already difficult to position all essential equipment controls and switches to be within easy reach of the pilot population<sup>4</sup>. This problem will be considerably exacerbated if this reach requirement is to be extended to include the Italian pilot population. Increased adjustment of seating, rudder pedal and other controls will be required.

REF 3



Though the problem is not, perhaps, quite so acute, similar difficulties will be experienced in designing rear cabin consoles to accommodate the 3rd to 99th percentile range of operators for both populations<sup>5</sup>.

In the rear cabin; if CRT or other displays have to be viewed frequently or for long periods, it is important to position the displays so that an optimum viewing angle of  $0^{\circ}$  up and  $30^{\circ}$  down is achieved<sup>3</sup>. The critical operator dimension in this case is sitting eye height, for which the Italian pilot mean is equivalent to only the 11th percentile RAF aircrew. Thus, if a satisfactory eye height is to be achieved for all operators, some additional seat adjustment will be required.

Fig 10 shows the range of seat adjustment to accommodate a range of 5th to 95th percentile RAF aircrew, when operators are required to monitor a CRT display. Further vertical and fore and aft seat adjustment will be required if this range is to include the 3rd to 99th percentile operators from both Italian and RAF populations.

#### 4 CONCLUSIONS

The Italian pilot and RAF aircrew populations differ in many respects. Although the Italians have similar body and limb circumferences to the RAF, their linear dimensions are generally less than those of RAF aircrew.

The critical measurements of knee height, buttock-knee length, sitting height and functional reach are all significantly less for the Italian pilots. This will increase the difficulty of accommodating both flying populations in cockpits and rear cabins of Anglo-Italian aircraft and greater adjustment will be required for seats and controls.

Table 1

Measurement (in mm)		Italian pilots			RAF aircrew		Italian flying cadets	
		Mean	Sd	Equivalent RAF %	Mean	Sd	Mean	Sd
1	Neck circumference	384	17.9	57	382	15.9	374	13.3
2	Vertical trunk circumference	1625	70.3	50	1625	65.5	1620	58.7
3	Chest circumference	975	57.4	55	972	57.0	949	41.4
4	Waist circumference	854	77.6	50	857	70.0	808	49.8
5	Buttock circumference	963	51.1	31	989	50.1	967	43.1
6	Wrist circumference	174	7.9	50	174	9.5	174	7.5
7	Thigh circumference	551	37.6	31	570	38.7	559	31.6
8	Calf circumference	367	23.0	54	367	21.5	375	24.1
9	Ankle circumference	225	12.0	52	225	12.2	231	13.3
10	Crotch height	809	42.7	16	854	43.0	840	44.4
11	Crotch length	671	39.7	71 (?)	641	53.2	666	31.4
12	Triceps skinfold thickness	12	5.0	65	11	3.9	11	4.2
13	Subscapular skinfold thickness	16	6.7	77	13	4.8	12	3.7
14	Fingertip height standing	639	32.8	19	671	34.4	648	31.3
15	Shoulder height standing	1399	60.6	4	1504	58.9	1427	57.9
16	Waist height standing	1018	49.0	14	1074	51.4	1050	49.4
17	Cervicale height standing	1468	59.2	20	1517	58.5	1498	58.7
18	Stature	1717	60.6	20	1770	62.0	1753	63.5
19	Foot breadth	101	4.5	93 (?)	95	4.4	103	3.8
20	Ball of foot circumference	251	11.1	55	250	11.6	254	9.5
21	Foot length	265	10.5	52	266	12.1	268	11.9
22	Elbow wrist length	278	12.8	25	288	14.2	286	14.1
23	Hand length	190	7.9	46	191	9.8	192	9.4
24*	Knee height sitting	538	25.8	22	559	25.4	553	26.1
25*	Functional reach	745	34.7	5	802	35.8	764	34.2
26	Elbow rest height sitting	227	23.4	20	248	24.5	222	22.3
27*	Buttock-knee length sitting	587	26.2	24	608	26.9	601	25.6
28	Bideloid breadth	475	21.7	68	466	20.8	469	17.9
29	Biacromial breadth	406	17.2	47	407	19.2	407	17.5
30	Hip breadth, sitting	362	18.5	39	368	19.5	364	17.4
31	Stool height	402	21.0	20	424	24.3	418	23.5
32	Thigh clearance height	165	11.7	72 (?)	158	12.2	164	10.2
33	Shoulder height sitting	618	27.5	4 (?)	666	26.2	620	28.4
34*	Sitting eye height	786	31.3	11	824	30.8	793	30.5
35*	Sitting height	903	33.0	15	936	36.9	914	31.8
36	Head breadth	156	5.3	44	158	5.4	156	6.0
37	Bitracion - coronal arc	356	11.9	60 (?)	353	12.6	359	11.8
38	Head circumference	558	12.3	27	577	13.6	569	13.1
39	Menton to vertex	224	8.1	30	230	10.1	226	10.1
40	Tracion to vertex	130	5.1	49	130	6.4	132	5.7
41	Nasion to vertex	104	6.3	40	106	9.6	106	7.0
42	Head length	194	6.4	26	199	6.4	194	6.1
43	Tracion to back of head	94	6.4	15	101	6.9	94	6.6
44	Menton to back of head	189	8.4	18	200	10.7	190	7.7
45	Maximum head diagonal from menton	258	7.0	33	262	7.7	259	7.4
46	Bitracion diameter (?)	146	5.0	92 (?)	139	5.0	146	4.4
47	Weight (kg)	73.6	9.4	46	75.0	8.8	73.0	7.7
48	Age	30.8	6.6	50	30.8	6.5	21.1	1.4

\* Critical dimensions

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<u>No.</u>	<u>Author</u>	<u>Title, etc</u>
1	H.T.E. Hertzberg E. Churchill C.W. Dupertuis R.M. White A. Damon	Anthropometric survey of Turkey, Greece and Italy. Pergamon Press, London, 1963
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5	K. Biggin	Anthropometric design of the WG 34 rear crew console. Westland Helicopters Ltd, Avionics Working Paper 51/80, July 1980

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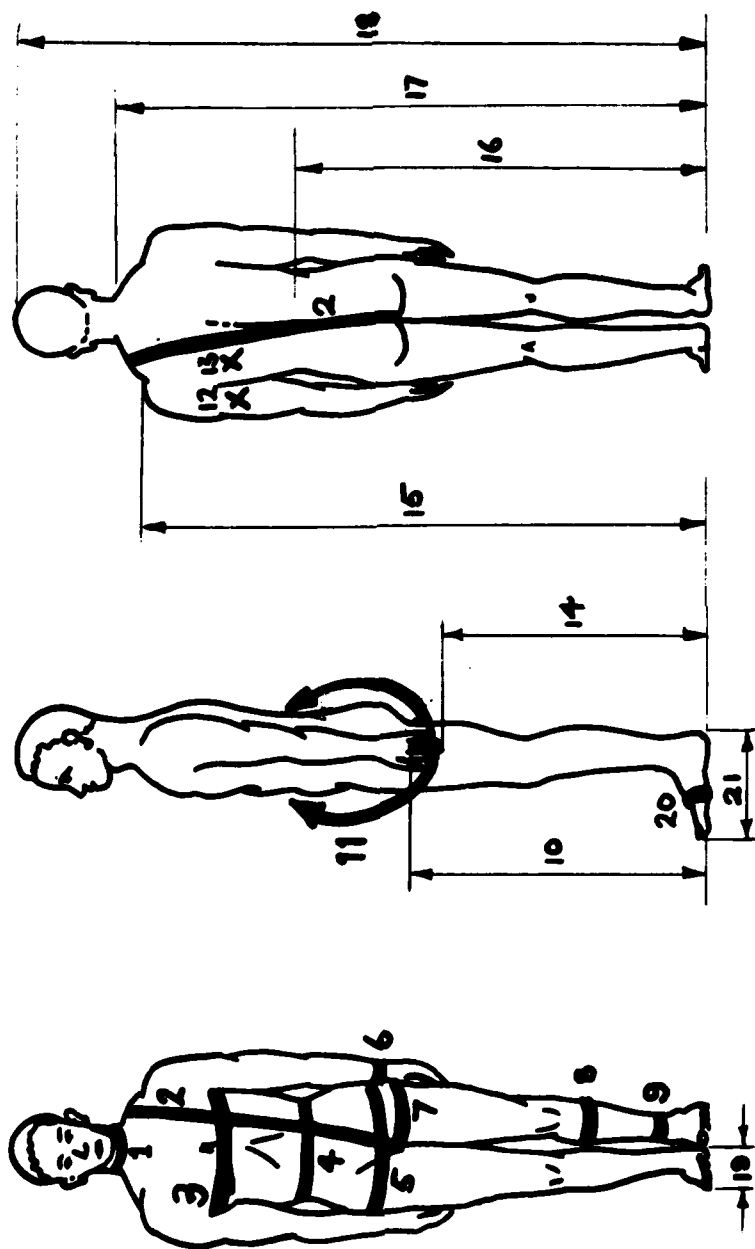


Fig 1 Standing measurements

Fig 2

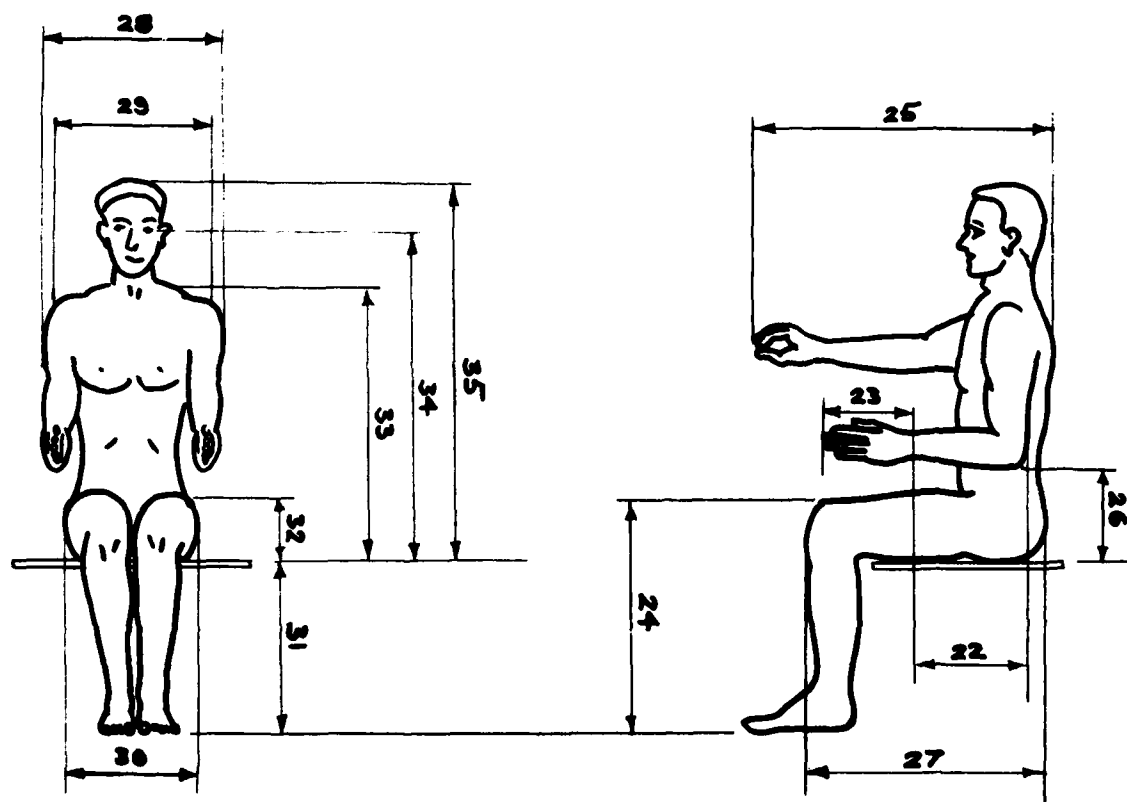


Fig 2 Seated measurements

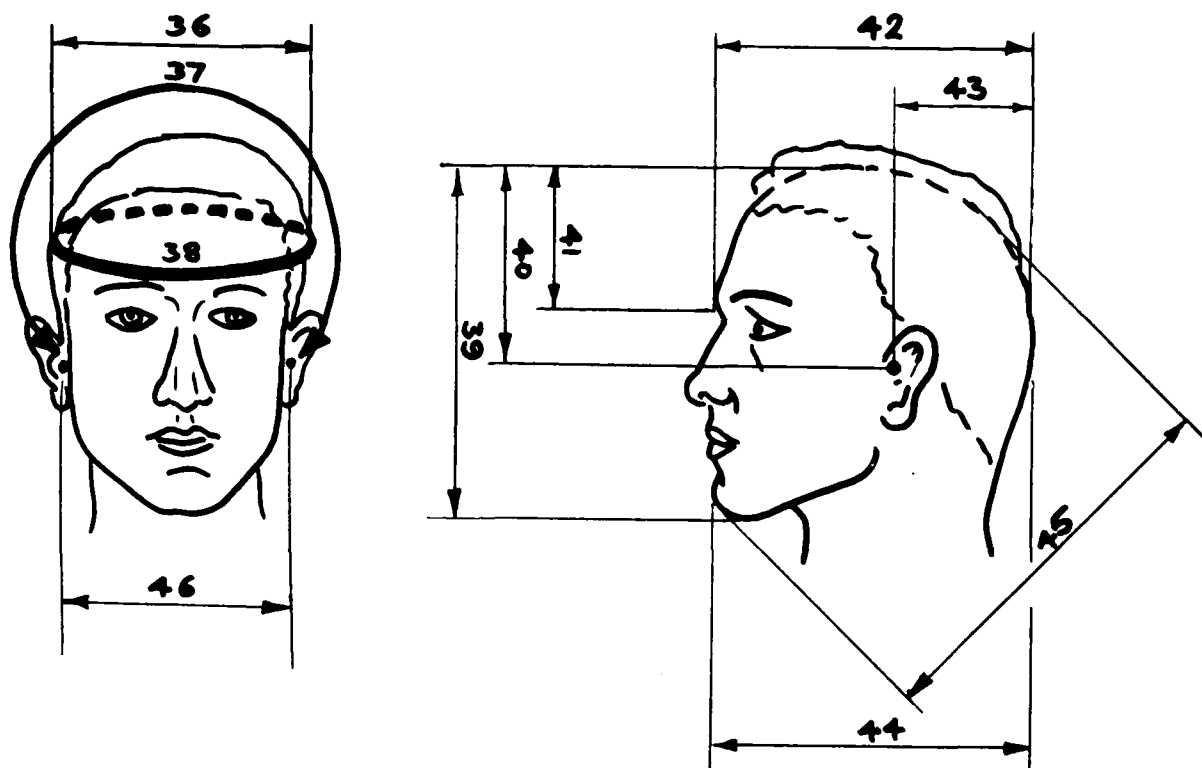


Fig 3 Head measurements

Fig 4

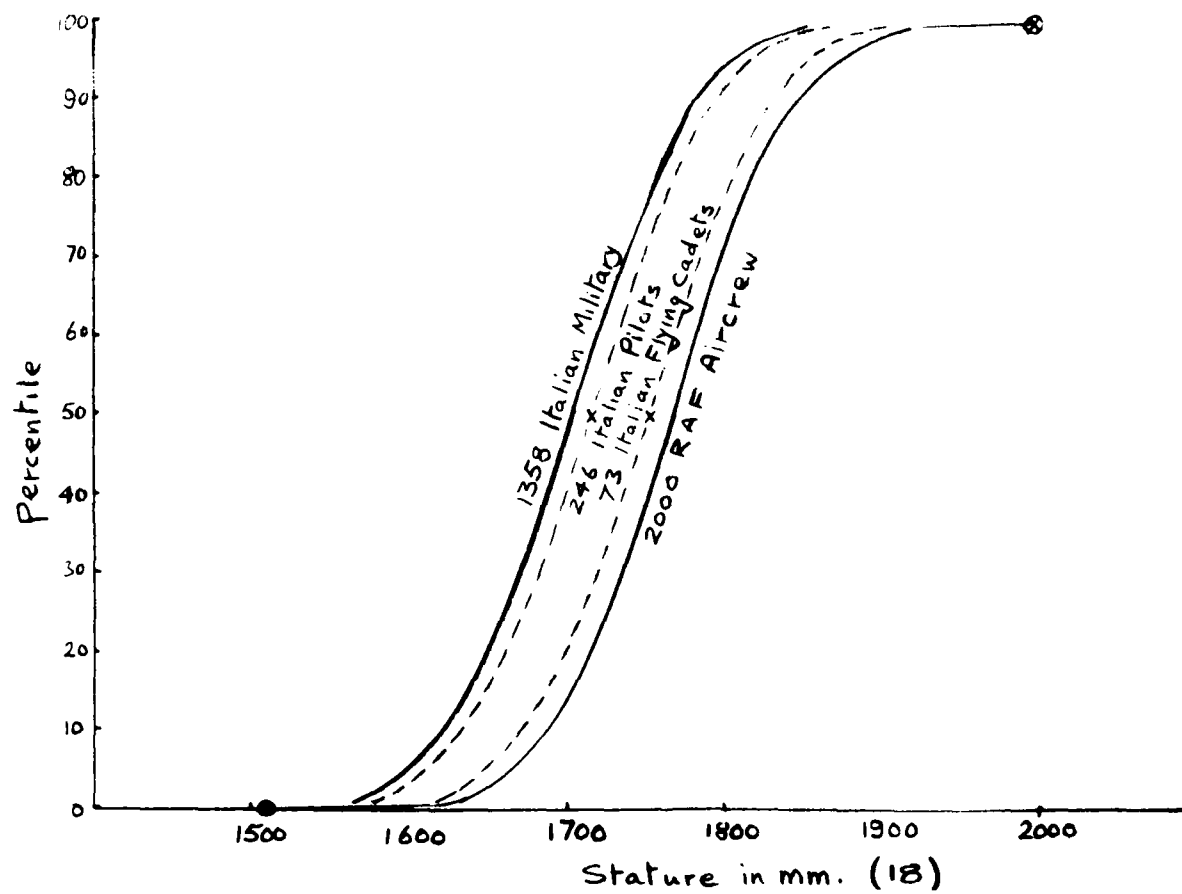


Fig 4 Stature distributions

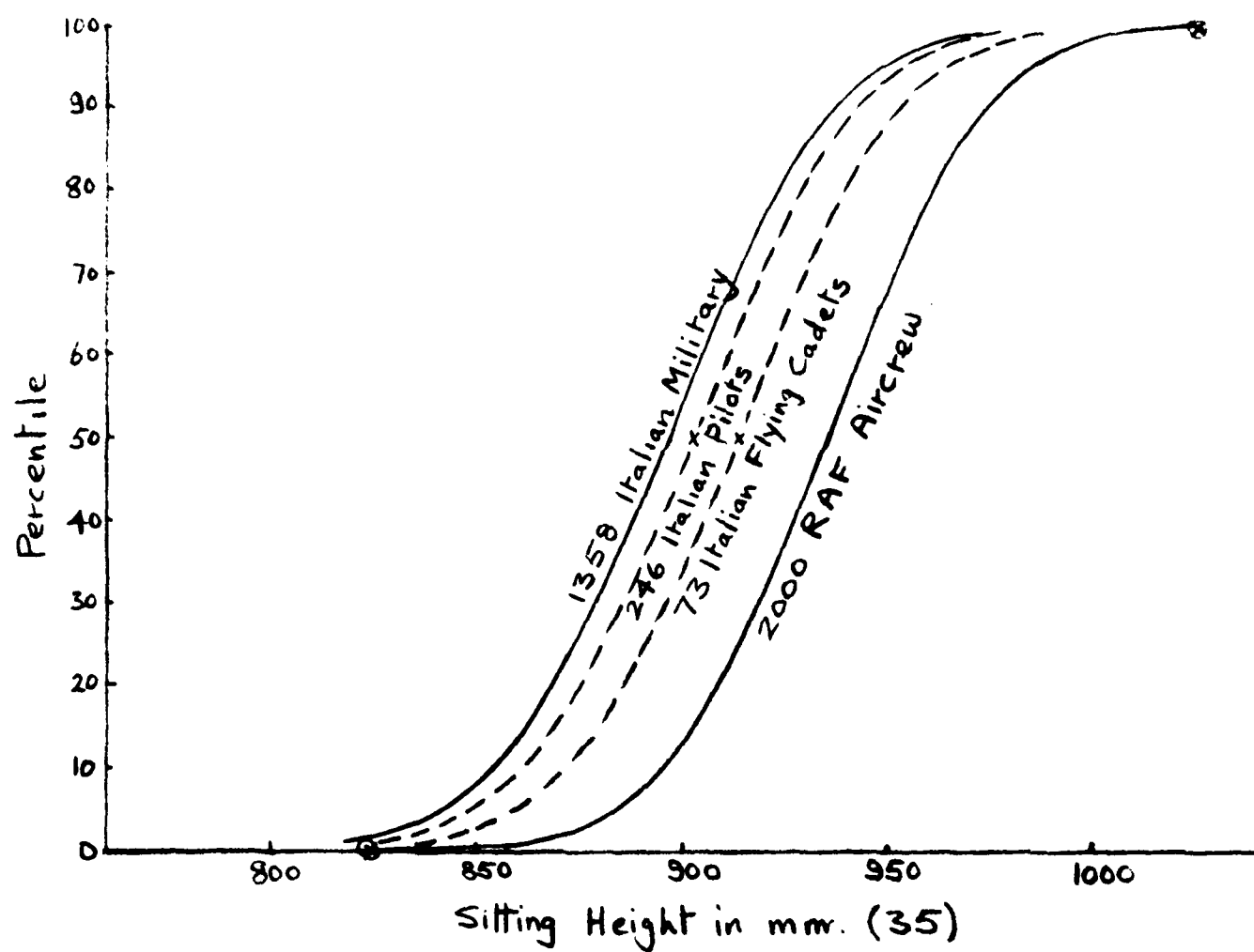


Fig 5 Sitting height distributions



Fig 6

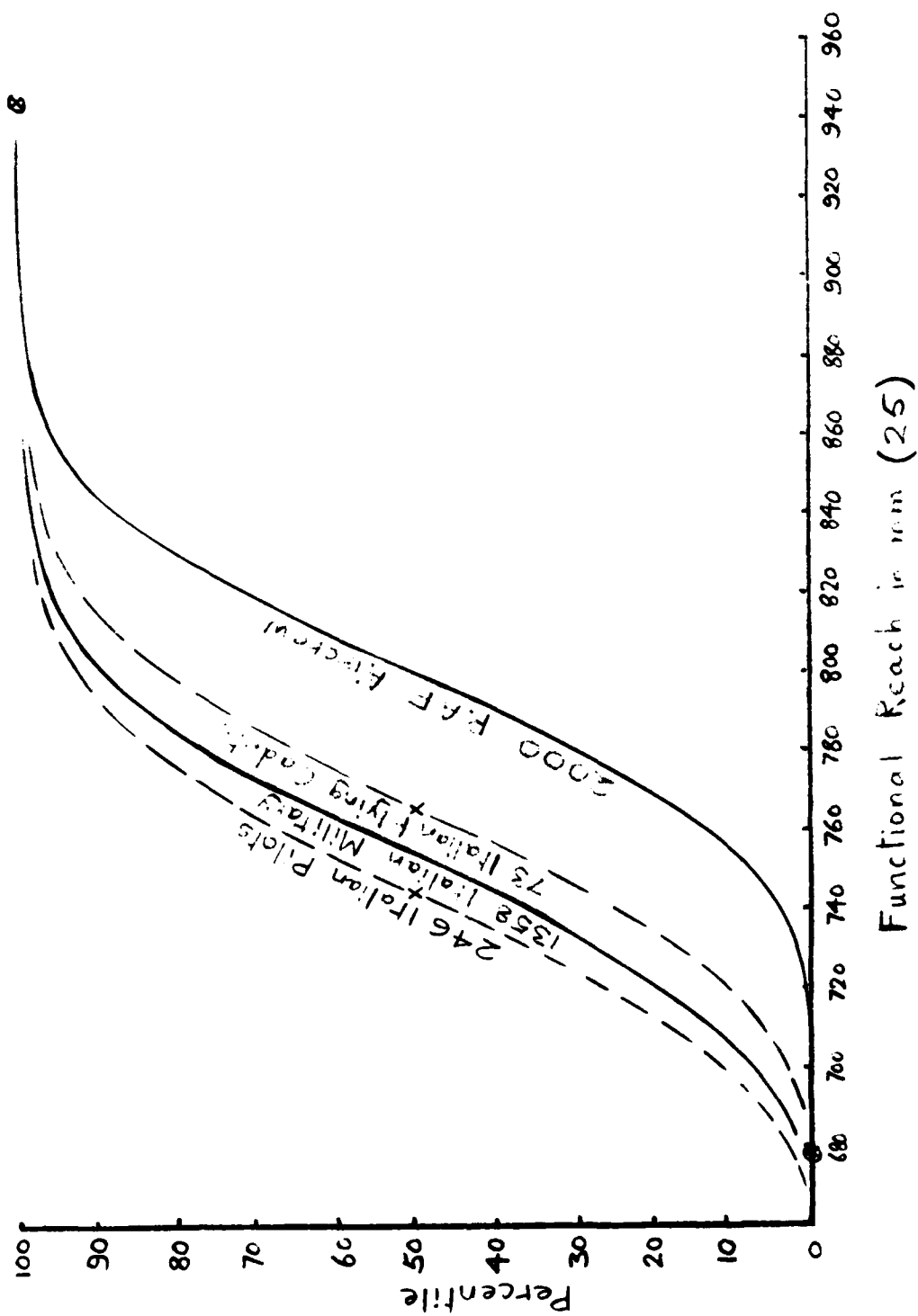


Fig 6 Functional reach distributions

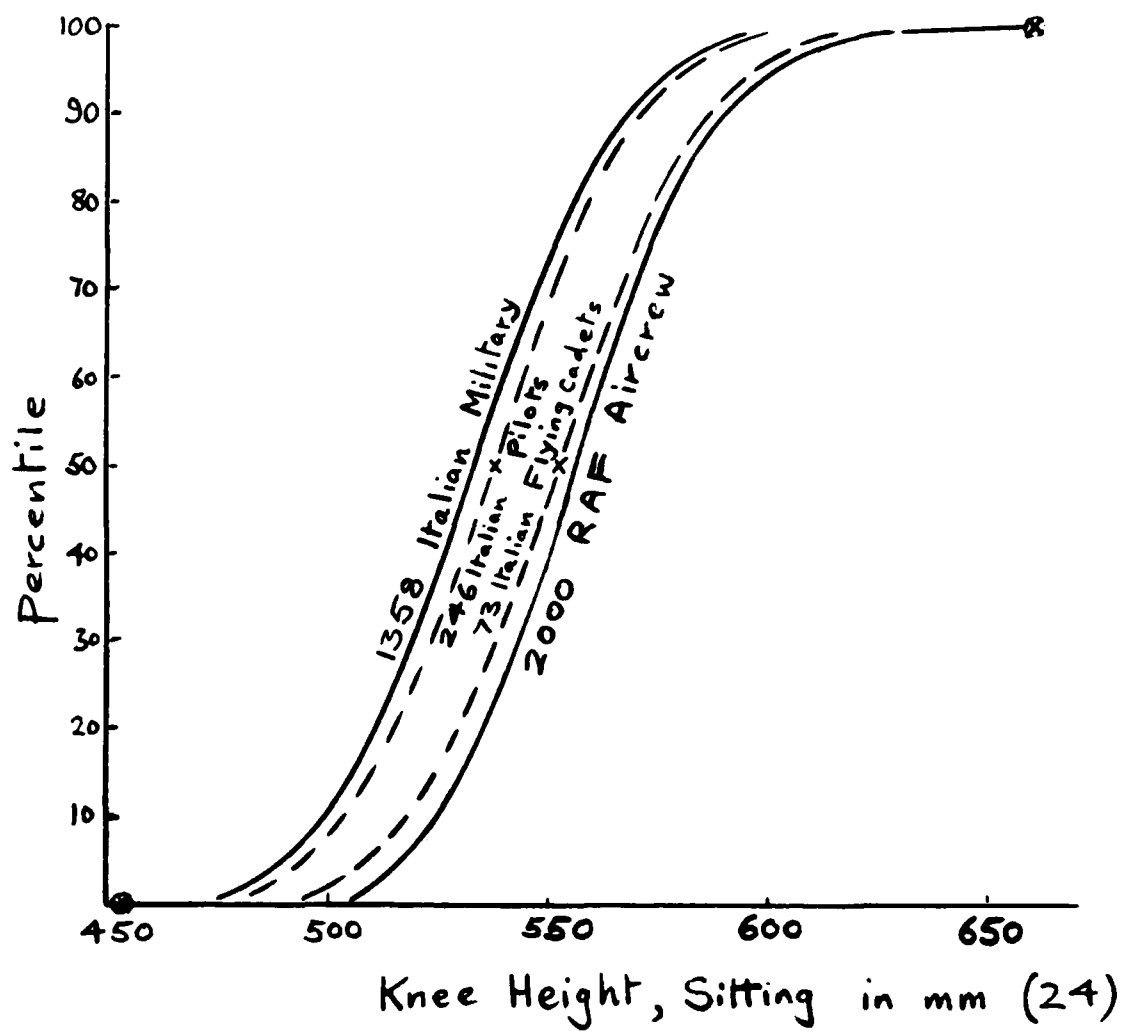


Fig 7 Sitting knee height distributions

Fig 8

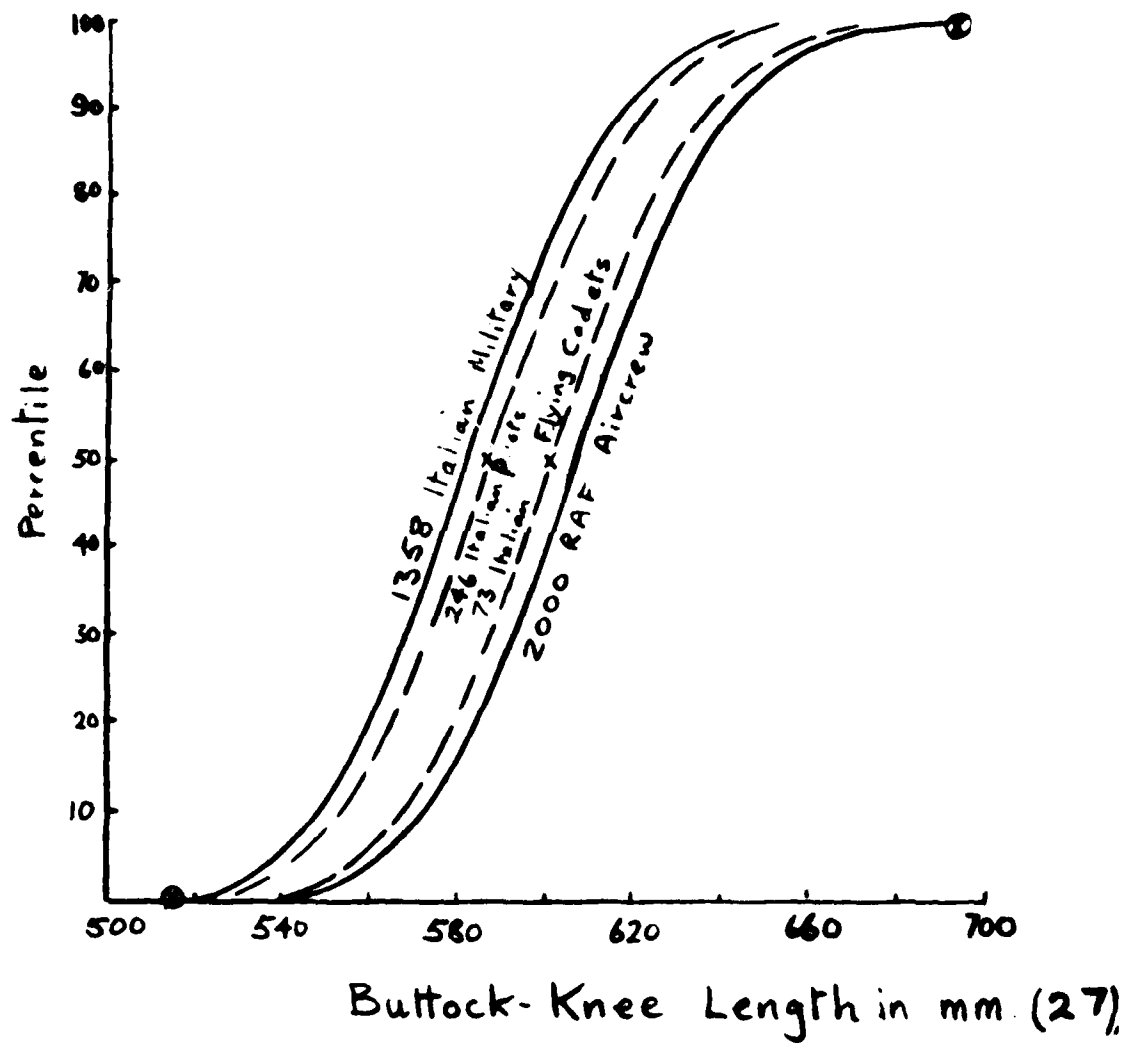


Fig 8 Buttock-knee length sitting distributions

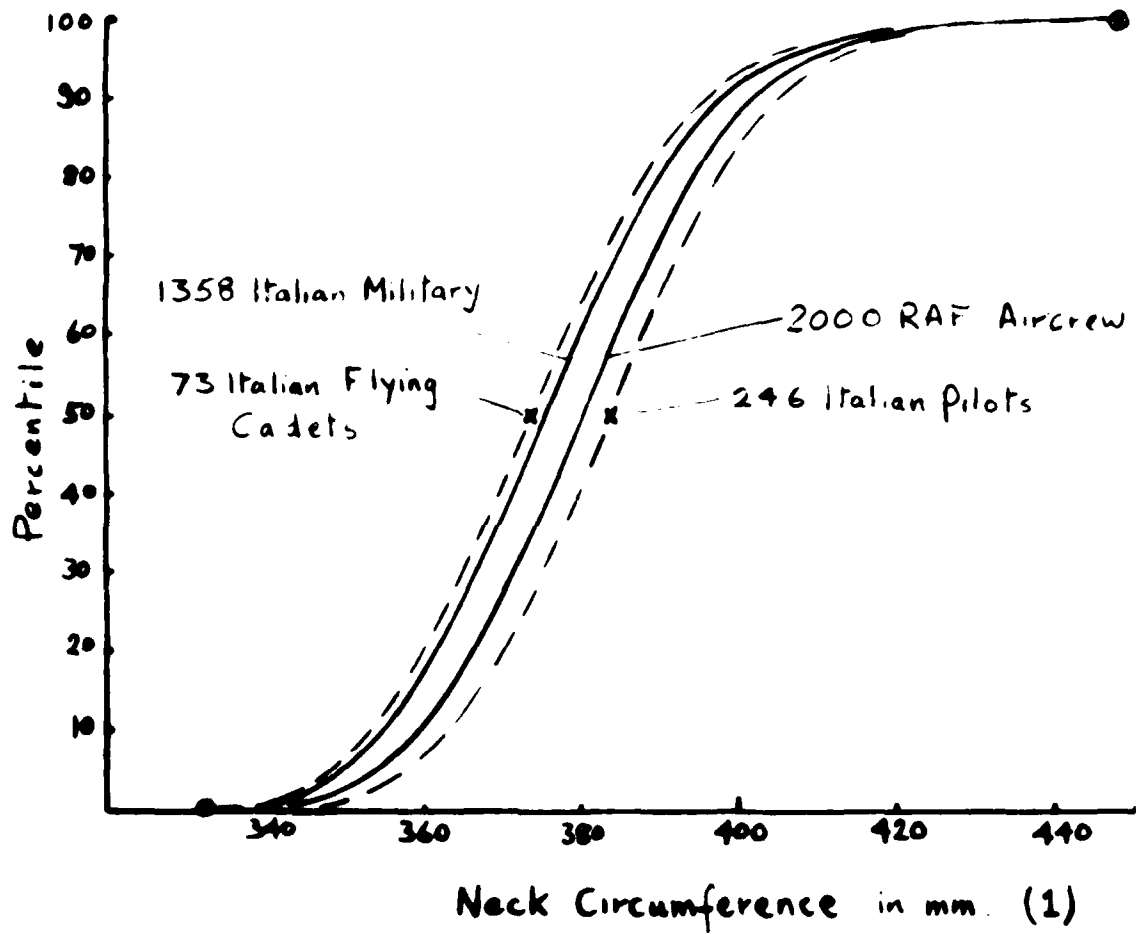


Fig 9 Neck circumference distributions

Fig 10

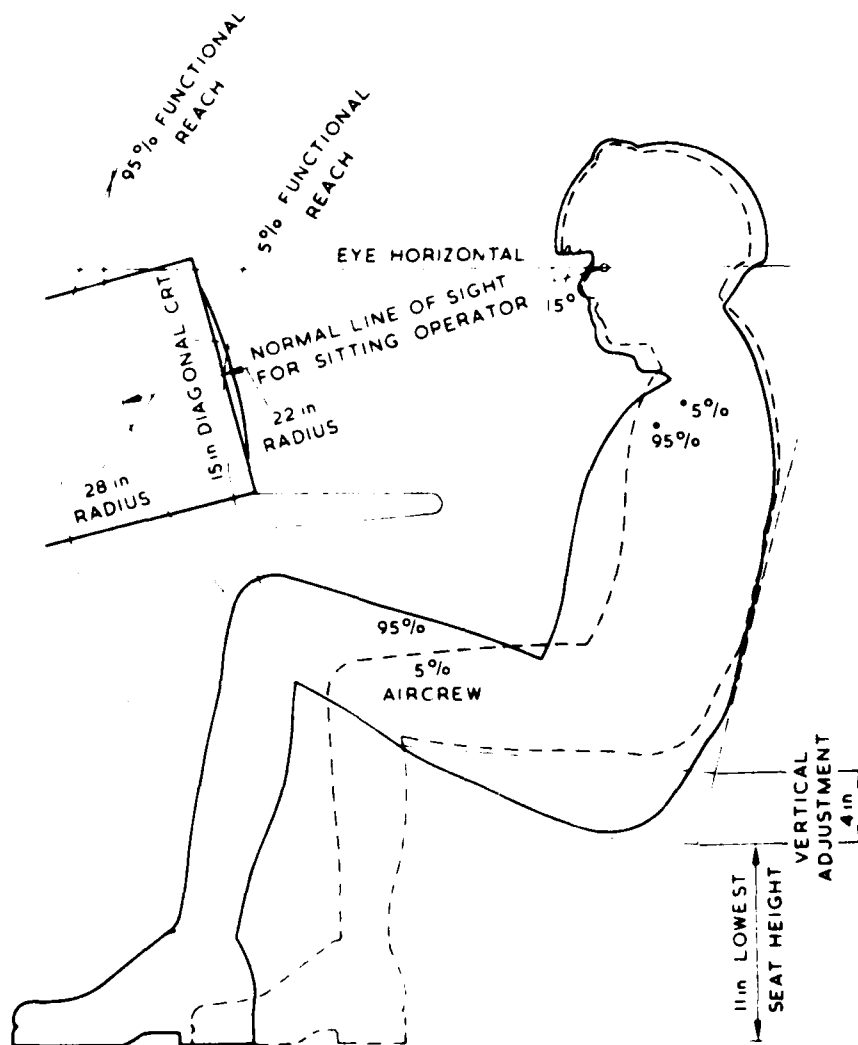


Fig 10 Seated 5th and 95th percentile RAF aircrew viewing a display

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16. Descriptors (Keywords) (Descriptors marked * are selected from YNMF) Ergonomics. Anthropometry.			
17. Abstract In view of proposed Anglo-Italian aircraft projects such as the T-4, it was decided that anthropometric measurements common to two population surveys have been compared. Means and standard deviations have been taken from Hartberg's anthropometric survey of Italian pilots and from the survey of 2000 RAF aircrew.  The figures generally show that the Italian pilots have smaller body dimensions than the RAF aircrew. The Italian pilots' body dimensions are considerably less than those of the RAF aircrew. These differences must be taken into account when designing cockpit and other cabin equipment.			

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